Supersonic Tunnel (SST)

DNW's Fastest Wind Tunnel for Simulation of Supersonic Flows up to Mach 4

German-Dutch Wind Tunnels

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Supersonic Tunnel (SST)

Key Aspects at a Glance

Type of wind tunnel	Blow-down, supersonic
Mach number	1.32 – 4.0
Test section size(s)	1.2 m x 1.2 m
Total pressure	200 – 1400 kPa
Reynolds number (max, l_{ref}=0.1 √A)	14 × 10^6
Temperature range	~290 K
Contraction	Variable nozzle
Drive power	600 m^3 dry air at ~40 bar
Auxiliaries	Air supply: ~4 kg/s at 17 bar
	Power supply up to 1000 VDC

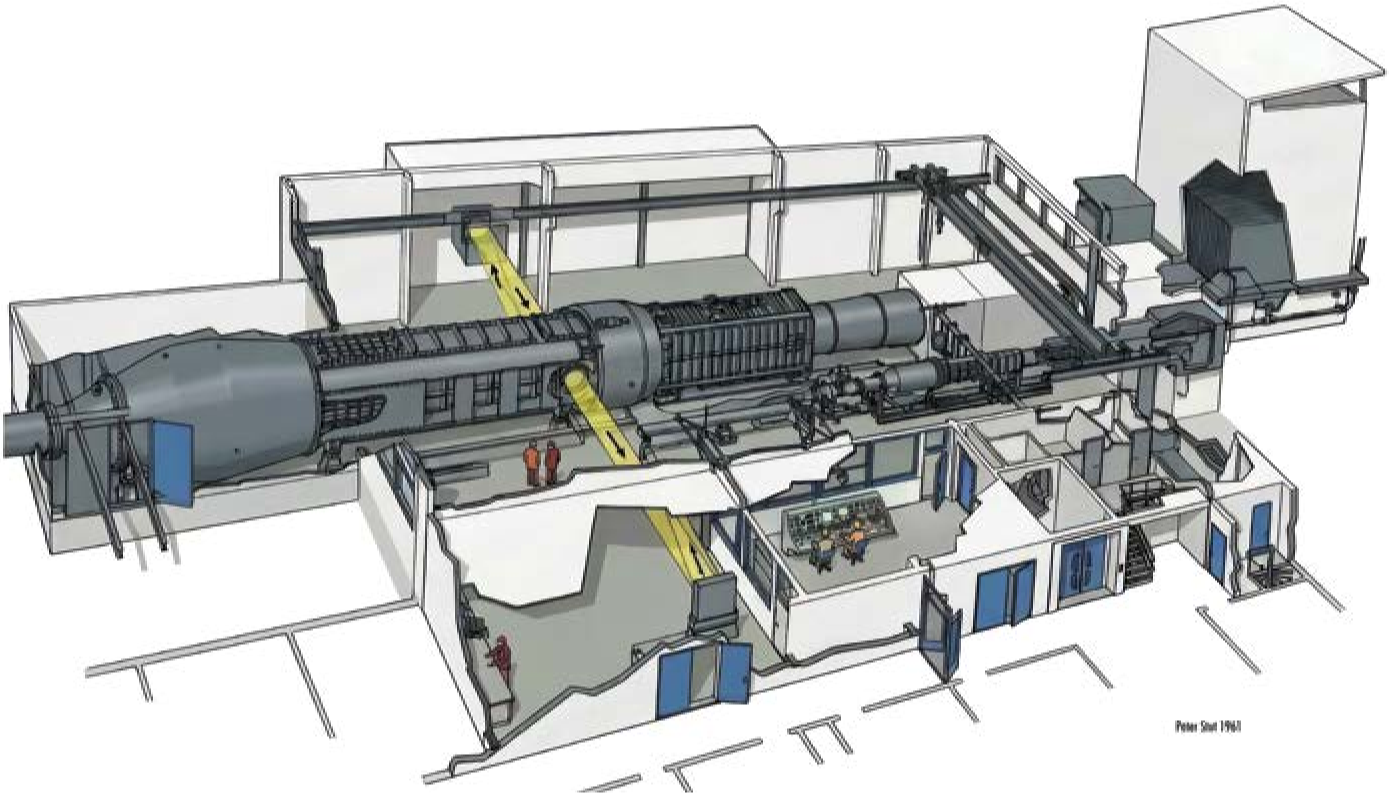


Illustration of DNW-SST wind tunnel and its operational environment

The DNW Supersonic Tunnel (SST) extends DNW's experimental capabilities seamlessly into the supersonic flow regime, forming the high-speed continuation of the High-Speed Tunnel (HST).

Together, HST and SST enable aerodynamic and propulsion–airframe integration testing from high-subsonic and transonic conditions into fully supersonic regimes.

The SST is specifically optimised for applications where compressibility effects, shock-dominated flow physics, supersonic inlet behaviour, and jet–airframe interactions govern overall system performance and operability.

A key aspect of the SST's positioning is its clear differentiation from facilities such as the Transonic Wind Tunnel Göttingen (TWG). While TWG focuses on smaller-scale, more academic and fundamental investigations, the SST is tailored to applied, configuration-level testing with a strong emphasis on integrated configurations, and industrial relevance.

This positioning makes the SST the preferred facility within DNW for customers requiring high-fidelity supersonic aerodynamic, intake, and jet interaction data as part of their development programmes.

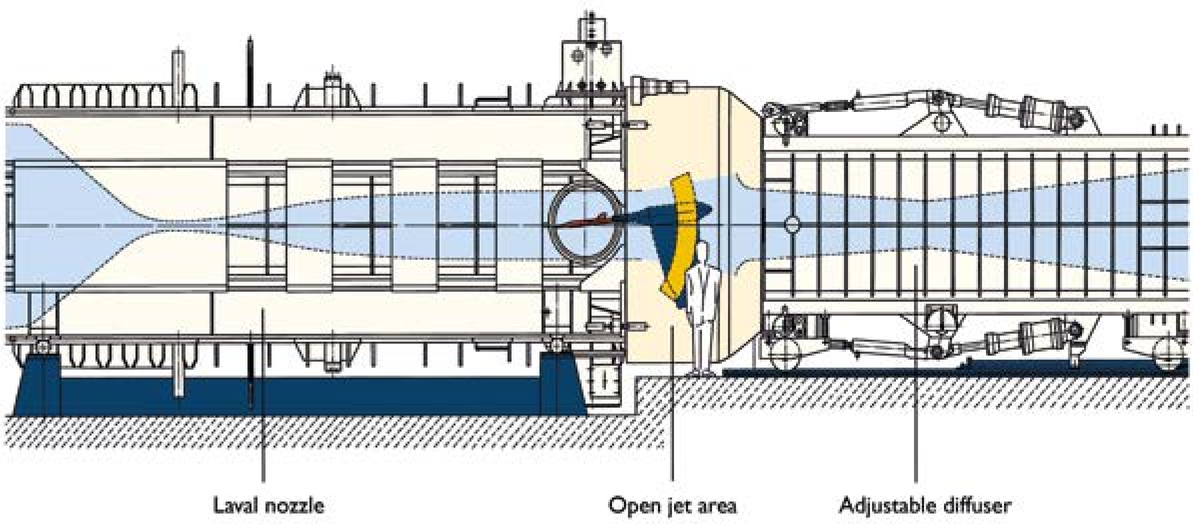
Why Supersonic Testing

Despite continuous progress in numerical simulation, experimental testing remains indispensable in the supersonic regime. The strong nonlinearities introduced by shock waves, boundary-layer interactions, and separated compressible flows make reliable prediction difficult without high-quality validation data.

Supersonic wind tunnel testing is essential to:

- resolve shock structures and shock–boundary-layer interactions,
- characterise aerodynamic loads and moments in compressible regimes,
- assess supersonic inlet and nozzle performance,
- investigate jet–airframe interactions,
- validate CFD methods in high-speed flow regimes,
- reduce risk for flight, re-entry and high-speed vehicle programmes.

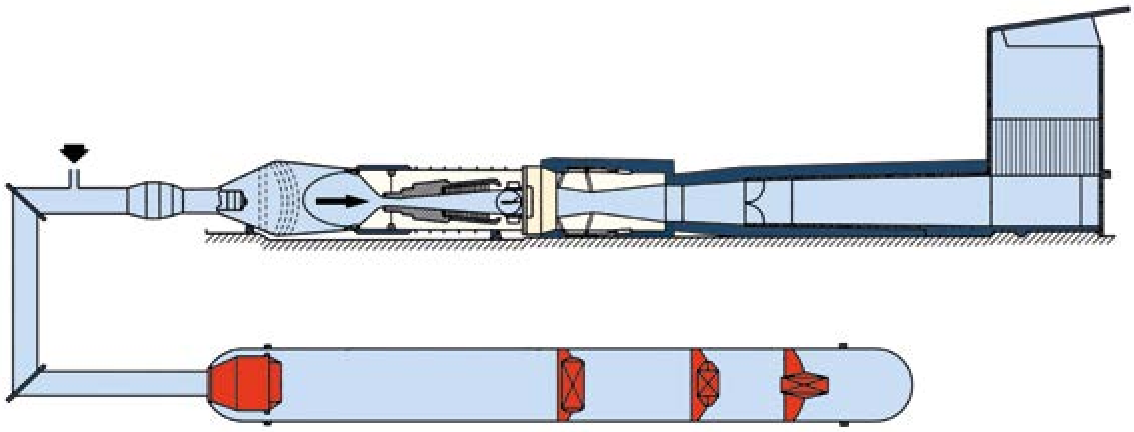
The SST provides controlled, repeatable test conditions that enable systematic exploration of these phenomena.



DNW-SST test section

Wind Tunnel Configuration

The SST is a blow-down supersonic wind tunnel designed for high-fidelity aerodynamic and propulsion–airframe integration testing in shock-dominated flow regimes. The facility is supplied by a large dry-air storage system, enabling stable stagnation conditions and highly repeatable operating points.



DNW-SST air circuit

A defining feature of the SST is its adjustable nozzle contour system, which allows the nozzle geometry to be adapted to the desired Mach number without exchanging hardware. This concept enables efficient transitions between operating points, high test productivity, and consistent flow quality across the full Mach range.

Upstream of the nozzle, flow conditioning is achieved using a carefully designed settling chamber equipped with multiple layers of mesh screens, ensuring low turbulence intensity and high spatial uniformity.

Downstream of the nozzle, the flow enters a rectangular test section, followed by a free-jet region in which the model support system is located. This configuration provides a well-defined core flow while offering excellent accessibility for model installation, instrumentation and configuration changes.

The diffuser and free-jet chamber form a movable assembly that can be translated pneumatically, significantly reducing model changeover time and improving operational efficiency.

Large optical-quality sidewall windows provide direct optical access to the test section and free-jet region, enabling flow visualisation by means of the Schlieren technique.

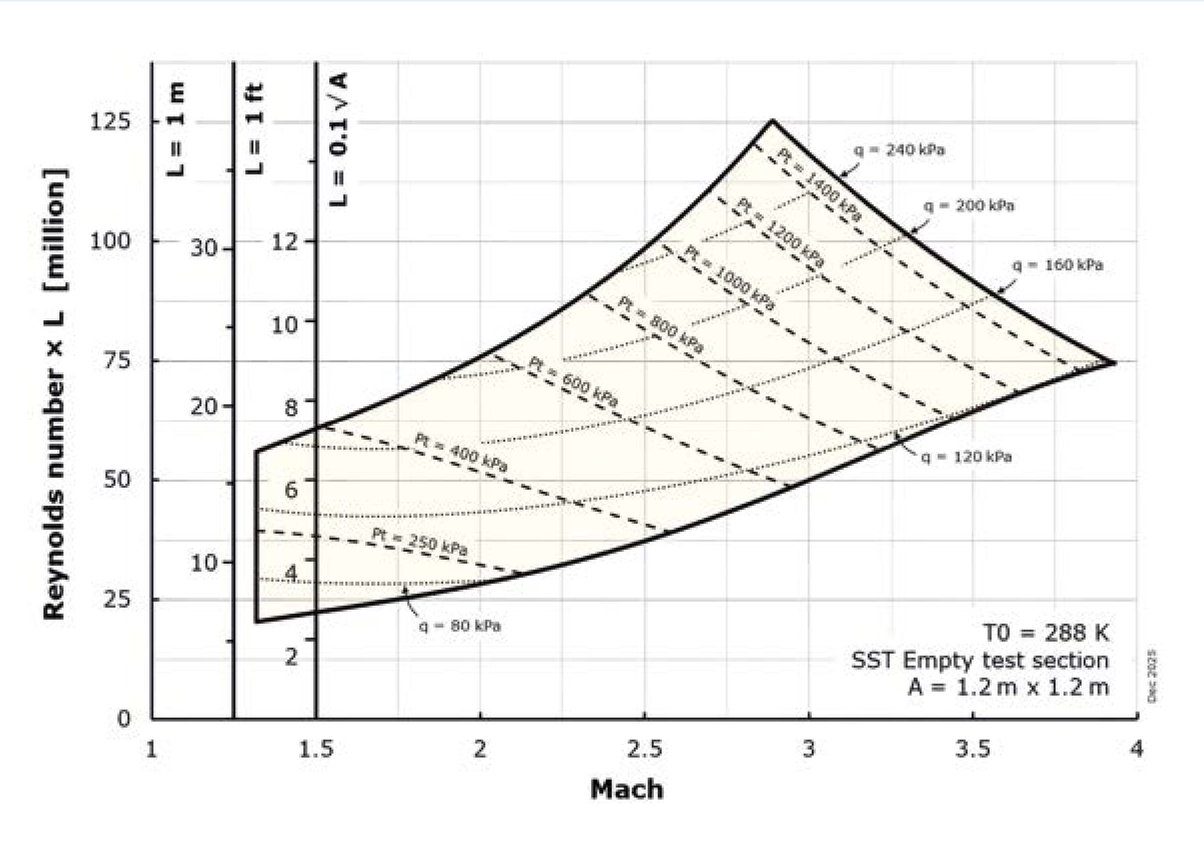
To protect models during start-up and shutdown transients—particularly at higher Mach numbers—the SST is equipped with proximity plates that can be deployed to form a protective duct around the model.

Key Flow Parameters & Operating Envelope

The SST provides stable, well-characterised supersonic flow over a wide Mach number range.

Key flow characteristics include:

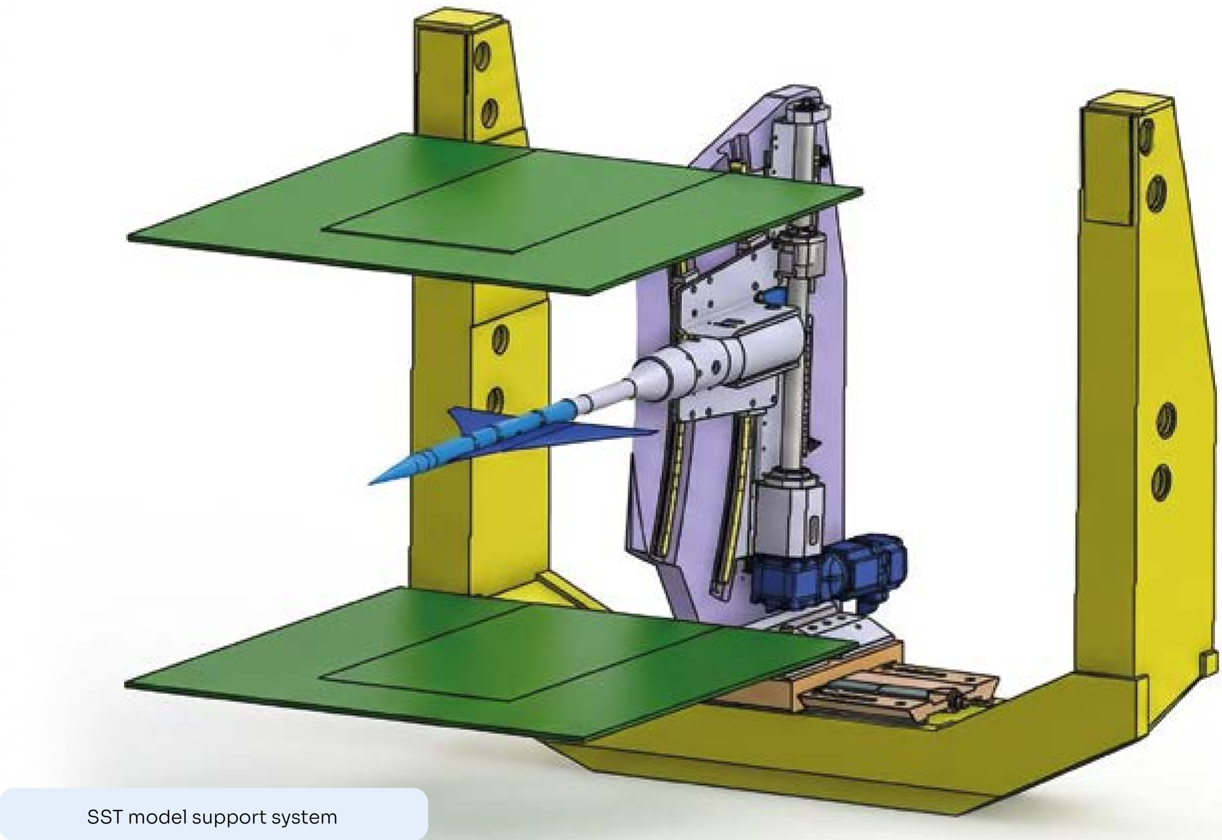
- Mach number range: 1.32 – 4.0
- Adjustable Mach setting via adjustable nozzle contour
- Calibrated Mach points: 1.33, 1.45, 1.59, 1.74, 1.90, 2.09, 2.29, 2.52, 2.77, 3.04, 3.32, 3.63, 3.94
- Mach number repeatability: ±0.002 to ±0.005 (Mach dependent)
- Maximum stagnation pressure: 1,470 kPa (Mach dependent structural limits)
- Stagnation temperature: ≈ 290 K, actively stabilised
- Test section cross-section: 1.20 m × 1.20 m (Mach dependent)
- Reynolds number range (reference length 0.1 √A) up to 14×10^6 (Mach dependent)
- Typical constant-pressure run time: 40–50 s (Mach dependent)
- Typical productivity: ~1 run per hour; 8-14 runs per day



Mach-Reynolds envelope of DNW-SST

Model Support & Load Measurement Capabilities

The SST features dedicated supersonic model support systems optimised for high-load and high-dynamic-pressure conditions.



SST model support system

Key characteristics include:

- Sting-mounted full-model support systems,
- A remotely controlled primary degree of freedom (typically angle of attack),
- Potentially remote controlled second parameter setting (e.g. ejector plug)
- Manual pre-set side-slip angle capability,
- Optional alpha shifter enabling rapid incidence changes from 0° to 20° within approximately 0.5 s.

The model support carriage is guided along a circular track and driven by an electric actuator, enabling fast and repeatable sweep manoeuvres.

Aerodynamic loads are measured using internal strain-gauge balances. The balance technology is shared with the HST and the Transonic Wind Tunnel Göttingen (TWG), enabling consistent load measurement methodologies across facilities.

Schlieren visualisation

Measurement & Diagnostic Techniques

The SST offers a comprehensive suite of measurement and diagnostic capabilities, aligned with DNW's portfolio-wide standards.

Available techniques include:

- High-accuracy force and moment balances (internal and external)
- High-density static and unsteady pressure measurement systems
- Schlieren visualisation for compressible flow phenomena
- Stereoscopic pattern recognition (SPR) for model deformation and attitude measurement
- Intake aerodynamics using plug-ejector techniques

The use of common or closely related measurement systems across DNW facilities allows techniques developed and validated in one facility to be efficiently applied in others. This cross-facility consistency is a key element of DNW's experimental quality and portfolio synergy.

High testing productivity is enabled by DNW's GAIUS wind tunnel control, automation and data-acquisition system, which is deployed consistently across LLF, LST, ECF, HST and SST. GAIUS supports scripted test execution, continuous sweeps and synchronised data acquisition, ensuring data quality while reducing overall test time.

Fighter testing

Propulsion Integration

In addition to external aerodynamics, the SST supports a broad range of propulsion-related and integrated supersonic investigations, including:

- Supersonic intake and inlet performance testing,
- Nozzle and exhaust flow characterisation,
- Jet–airframe interaction studies,
- Plume–shock interaction investigations,
- Cold-flow simulation of propulsion systems.

The SST is particularly suited for studying the aerodynamic integration of propulsion systems under supersonic flow conditions, where shock structures and compressibility effects strongly influence intake operability and exhaust behaviour.

Supersonic aircraft testing

Typical Applications

The SST supports a wide range of industrial and research applications, including:

- Supersonic aircraft configuration testing
- Re-entry vehicle studies
- Missile and launcher aerodynamics
- Supersonic inlet and nozzle development
- Jet–airframe interaction investigations
- Weapon bay acoustics
- CFD validation in compressible-flow regimes

Customer Value & DNW Portfolio Synergy

The SST provides customers with:

- access to a wide supersonic Mach range in a controlled environment,
- high-fidelity data for shock-dominated and compressible flows,
- adequate testing workflows enabled by rapid model access and repeatable run conditions,
- seamless integration into staged experimental development programmes.

The SST does not operate in isolation, but as part of an integrated system of complementary facilities. Within this portfolio:

- LLF provides large-scale, multidisciplinary low-speed testing
- LST serves as a readily accessible development and pre-testing facility for both HST and LLF
- NWB enables dedicated low-speed aero-acoustic and multidisciplinary investigations
- HST delivers high-Reynolds-number transonic validation up to M = 1.3
- TWG offers highly flexible, smaller-scale continuous transonic and supersonic testing up to M = 2.2

This synergy of scales and speed regimes allows customers to execute coherent experimental programmes across multiple facilities, from early concept studies at smaller scale to large-scale high-fidelity validation.

This integrated approach differentiates DNW from isolated single-tunnel providers and enables customers to move from concept-level testing to large-scale validation within a single coordinated experimental ecosystem.

The SST extends DNW's experimental capabilities seamlessly into the supersonic flow regime, for customers requiring applied, configuration-level testing with a strong emphasis on industrially relevant test workflows.

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